AlphaCell™ SMU-F

Valve Regulated Lead Acid Battery

Technical Manual

AlphaCell SMU-F Valve Regulated Lead Acid Battery

Effective: February 2007

Alpha Technologies

AlphaCell SMU-F
Valve Regulated Lead Acid Battery

SMU-F-BATTERY

Effective Date: February 2007

member of The Group™

NOTE:

Photographs contained in this manual are for illustrative purposes only. These photographs may not match your installation.

NOTE:

Operator is cautioned to review the drawings and illustrations contained in this manual before proceeding. If there are questions regarding the safe operation of this product, please contact Alpha Technologies or your nearest Alpha representative.

NOTE:

Alpha shall not be held liable for any damage or injury involving its enclosures, power supplies, generators, batteries, or other hardware if used or operated in any manner or subject to any condition not consistent with its intended purpose, or is installed or operated in an unapproved manner, or improperly maintained.

Contacting Alpha Technologies: *www.alpha.com*

or

For general product information and customer service (7 AM to 5 PM, Pacific Time), call

1-800-863-3930,

For complete technical support, call

1-800-863-3364

7 AM to 5 PM, Pacific Time or 24/7 emergency support

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Tables and Figures

Safety Notes

Review the drawings and illustrations contained in this manual before proceeding. If there are any questions regarding the safe installation or operation of the system, contact Alpha Technologies or the nearest Alpha representative. Save this document for future reference.

To reduce the risk of injury or death, and to ensure the continued safe operation of this product, the following symbols have been placed throughout this manual. Where these symbols appear, use extra care and attention.

ATTENTION:

The use of ATTENTION is only for specific regulatory/code requirements that may affect the placement of equipment and installation procedures.

NOTE:

A NOTE gives readers additional information to help them complete a specific task or procedure.

CAUTION!

The use of CAUTION indicates safety information intended to PREVENT DAMAGE to material or equipment.

WARNING!

A WARNING presents safety information to PREVENT INJURY OR DEATH to the technician or user.

Battery Safety Notes

WARNING!

Lead-acid batteries contain dangerous voltages, currents and corrosive material. Battery installation, maintenance, service and replacement must be performed only by authorized personnel.

Chemical Hazards

Any gelled or liquid leakage from a valve-regulated lead-acid (VRLA) battery contains dilute sulfuric acid, which is harmful to the skin and eyes. Emissions are electrolytic, and are electrically conductive and corrosive.

To avoid injury:

- Servicing and connection of batteries shall be performed by, or under the direct supervision of, personnel knowledgeable of batteries and the required safety precautions.
- Always wear eye protection, rubber gloves, and a protective vest when working near batteries. Remove all metallic objects from hands and neck.
- Batteries produce explosive gases. Keep all open flames and sparks away from batteries.
- Use tools with insulated handles, do not rest any tools on top of batteries.
- Lead-acid batteries contain or emit chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. Battery post terminals and related accessories contain lead and lead compounds. Wash hands after handling (California Proposition 65).
- Wear protective clothing (insulated gloves, eye protection, etc.) when installing, maintaining, servicing, or replacing batteries.
- If any battery emission contacts the skin, wash immediately and thoroughly with water. Follow your company's approved chemical exposure procedures.
- Neutralize any spilled battery emission with the special solution contained in an approved spill kit or with a solution of one pound bicarbonate of soda to one gallon of water. Report a chemical spill using your company's spill reporting structure and seek medical attention if necessary.
- Always replace batteries with those of an identical type and rating. Never install old or untested batteries.
- Do not charge batteries in a sealed container. Each individual battery should have at least 0.5 inches of space between it and all surrounding surfaces to allow for convection cooling.
- All battery compartments must have adequate ventilation to prevent accumulation of potentially dangerous gas. Ventilation should prevent trapped hydrogen gas pockets from exceeding a 1% concentration as per regulation 70E of the National Fire Protection Agency (NFPA).
- Prior to handling the batteries, touch a grounded metal object to dissipate any static charge that may have developed on your body.
- Never use uninsulated tools or other conductive materials when installing, maintaining, servicing, or replacing batteries.
- Use special caution when connecting or adjusting battery cabling. An improperly connected or an unconnected battery cable can make contact with an unintended surface that can result in arcing, fire, or possible explosion.
- A battery showing signs of cracking, leaking, or swelling should be replaced immediately by authorized personnel using a battery of identical type and rating.

Equipment Cautions

- Do not operate NiCd and lead-acid batteries in the same room. NiCd emissions will neutralize the lead-acid solution, rendering the battery useless.
- Overcharging the battery can result in a loss of capacity and excess release of gas.

Recycling and Disposal Instructions

Spent or damaged batteries are considered environmentally unsafe. Always recycle used batteries or dispose of the batteries in accordance with all federal, state and local regulations.

1.0 Introduction

The SMU-F range of Valve Regulated Lead Acid (VRLA) batteries is designed to meet the needs of the wireless communications industry. Safety, reliability and a long service life in standby applications are the result of an industry-leading manufacturing technology and a product design purpose-built for the requirements of a wireless communications network.

Alpha Technologies also offers a full line of racking solutions to accomodate the SMU-F range of batteries. Front-terminal SMU-F batteries provide easy access to terminals for installation and maintenance, eliminating the need to purchase expensive sliding mechanisms to provide terminal access.

The SMU-F range includes 8 models – a revolutionary idea to reduce space requirements and minimize the number of terminations – to make it easier to install and maintain these batteries. Other features of the SMU-F range include:

- No additional water is needed throughout their life thus reducing maintenance costs as compared to vented (flooded) batteries.
- Meets the requirements of modern electronic equipment and is compatible with normally available recharging systems.
- Compact construction and excellent performance at high rates of discharge provides big savings in volume and weight as compared to conventional flooded, vented batteries.
- Because there are no perceptible amounts of gas emissions under normal operating conditions, batteries can be installed in the same environment where people live and work.
- Substantial savings in installation and maintenance costs compared to conventional vented batteries.
- No special rooms are required and only minimal maintenance is needed during the life of the battery.
- Smaller, lighter, and more compact than traditional batteries, SMU-F batteries, with integrated handles, are easy to move.
- Delivered filled and charged for immediate use.

1.1 Main Applications

Wireless Communications

SPACELL SMU-F batteries have a proven track record of performance in many parts of the communications network including Central Office, Huts, CEV's and Remote Terminal cabinets.

Uninterruptible Power Supplies (UPS)

The low internal resistance Absorbent Glass Mat (AGM) FA batteries make them a good choice for U.P.S. applications, especially for Industrial U.P.S. and extended run-time applications.

1.2 Specifications and General Information

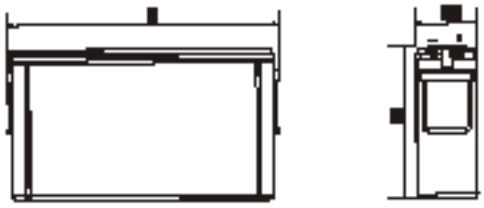
Specifications are subject to change without notice.

Type	Length (in/mm)	Width (in/mm)	Height (in/mm)	Weight (lb/kg)	Standard Stud Size *
SMU-F 12-50-FR	15.4/390	4.1/105	8.9/227	47.4/21.5	8mm
SMU-F 12-75-FR	21.9/558	4.1/105	8.9/227	68.3/31.0	8mm
SMU-F 12-85-FR	15.6/395	4.1/105	10.6/270	69.5/31.5	8mm
SMU-F 12-105-FR	20.1/511	4.3/110	9.4/238	79.4/36.0	8mm
SMU-F 12-125-FR	21.9/558	4.9/125	10.6/270	108.0/49.0	8mm
SMU-F 12-155-FR	21.9/558	4.9/124	11.1/283	119.0/54.0	8mm
SMU-F 12-170-FR	21.9/558	4.9/124	12.2/310	129.8/59.0	8mm

*a 6mm stud size can be ordered as an option

Table 1-1, Mechanical Specifications

Fig. 1-1, Dimensions



Torque specifications

Torque specifications are **8.4Nm (75lbf-in).** Torque all terminal connections to the specified value. Improper torquing can result in loose connections or damaged terminals.

Electrolyte

The electrolyte is sulfuric acid with a specific gravity of 1.320 at 77ºF (25ºC) and has the same purity characteristics as other types of high quality lead acid batteries.

Short circuit

SMU-F batteries are designed to withstand a short circuit current for 1 minute without damage.

Cycling

The SMU-F range of batteries will deliver 200 cycles (at C_8 to 1.75Vpc and 77ºF (25ºC)).

Life

The end of service life of a battery is defined as the point at which the battery's actual capacity has reached 80% of its nominal capacity. The design life of the FA family of batteries is 15 years of float life. However, since users cannot often duplicate laboratory conditions, such as controlling temperature, voltage, and AC ripple, this period may vary. Battery life will decrease by roughly half for every 14.4–18ºF (8–10°C) above or below nominal operating temperature (68ºF (20°C)).

Low Voltage Interruption

Because the DC load will shut off if the voltage gets too low, damaging equipment, Alpha Technologies recommends the use of Low Voltage Disconnects (LVDs) to maximize battery life. LVDs protect sensitive equipment from low voltages, and prevent the battery from being over-discharged. LVDs can be placed on either the load or battery side.

A string of batteries is a series of individual 2V cells working together. After discharge, the voltages of individual cells vary based on the exact capacity of each cell. Most users try to terminate the load when the batteries reach 1.75Vpc to ensure no individual cells fall below 0 VDC. Cells that fall below 0 VDC are said to be reversed. Alpha Technologies strongly recommends that cells which have been reversed be replaced immediately.

1.2 Specifications and General Information, continued

Gassing

SMU-F batteries have a high recombination efficiency (>98%) and for cells operated at 68ºF (20ºC) under normal operating conditions venting is virtually negligible. The following gassing rates can be expected:

- 2 ml/Ah/cell/month at a float voltage of 2.27Vpc.
- 10 ml/Ah/cell/month at a recharge voltage of 2.40Vpc.

As hydrogen should never exceed 2% by volume in any enclosed space, all rooms or cabinets where batteries are installed should have natural ventilation and not be fully sealed. Customers should also be aware that hydrogen is very light and can “pocket” in portions of the room or cabinet. Designers should take this into account when designing the battery operating space.

Each cell has a one-way valve to permit the release of gases from the cell whenever the internal pressure exceeds the fixed safety value. The valve is rated at approximately 0.1 atmospheres (1.5 PSIG or 10 kPa).

Operation of batteries in parallel

When the required capacity is greater than the maximum available from our range, it is possible to connect batteries in parallel to obtain the desired capacity.

- Use only blocks of the same model
- Make all electrical connections of parallel circuits between the batteries as equal and symmetrical as possible (e.g., length and type of connector) to minimize possible impedance variations

Capacity

The battery capacity is rated in ampere hours (Ah) and indicates the quantity of electricity which can be supplied during discharge. The capacity depends on the quantity of the active materials contained in the battery (thus on dimensions and weight) as well as the discharge rate and temperature. The higher the discharge rate, the lower the available capacity. As batteries get colder, the available capacity is reduced. This is related to the kinetics of the electrochemical reactions and the resistivity of the electrolyte (see Fig. 1-2).

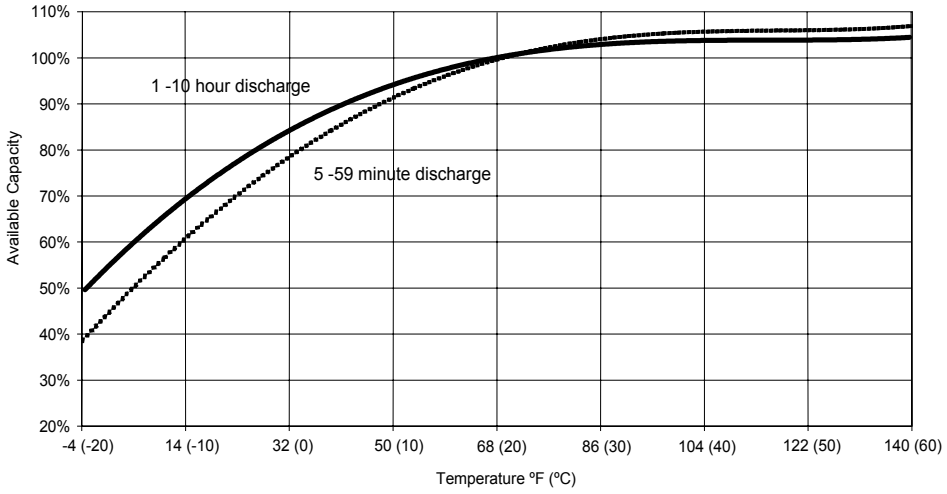


Fig. 1-2, Capacity Related toTemperature and Discharge Rate

2.0 Charging

NOTE:

Refer to your particular charger's manual for specific instructions regarding charger setup and operation.

During operation, verify batteries are:

- Float-charged in order to maintain a fully charged condition during the standby period.
- Completely recharged after a discharge. Recharge as soon as possible to ensure maximum protection against subsequent power outages. Early recharge also ensures maximum battery life.

While recharging procedures vary depending on the recharge time and battery life, generally charging is performed as follows:

- At a voltage equal to the float voltage and a low current (long recharge time);
- At a voltage not higher than 2.4Vpc and a high current (faster recharge).

The IU recharge method, also known as modified constant potential, has been used for many years and in a variety of applications. It satisfies the need to have the battery quickly recharged while ensuring maximum battery life.

1. Recharge at a constant current rate until the voltage reaches a pre-set value.
2. Maintain the pre-set voltage and decrease the current until a minimum defined value is reached.
3. Complete the recharge at a final constant voltage value equal to or less than that defined for float charge and decrease the current to the value used in float.

2.1 Float Charge

2.27V at 68ºF (20ºC) is the recommended voltage for float charge. This voltage ensures the maximum life of SMU-F batteries. These batteries can operate over a temperature range of -4ºF (-20ºC) to +140ºF (+60ºC). Performance and life are greatly reduced outside of this temperature range.

Temperature ºF (ºC)	Recommended Float (Vpc)
-4 (-20)	2.37
32 (0)	2.32
68 (20)	2.27
77 (25)	2.26
140 (60)	2.17

Table 2-1, Float Voltages

The equation to determine float voltage at a given temperature is:

$V = 2.32 – 0.0025 * T$

V = Float Voltage

T = Temperature

or

-2.5 mV per 1.8ºF (1ºC) temperature fluctuation outside of 68ºF (20ºC)

The minimum and maximum recommended voltages are 0.010V on either side of the determined voltage at a given temperature. Batteries floated at voltages above the range will have an increased risk of dry out, grid corrosion and thermal runaway. Batteries floated below the range will not receive enough charge, and will be subject to sulfation.

2.1 Float Charge, continued

Float Current

The normal float current observed in fully charged SMU-F batteries at 2.27Vpc at a temperature of 68ºF (20ºC) is approximately 30mA per 100Ah. Because of the nature of recombination phenomena, the float current observed in SMU-F batteries is normally higher than that of vented batteries and is not an indication of the state of charge of the batteries.

Thermal Runaway

Float current is primarily a function of voltage and temperature. As either voltage or temperature increases, the float current also increases exponentially. Much of the float current is going into the recombination reaction, which is exothermic. If the heat generated by recombination exceeds the rate at which heat can be transferred out of the battery (based on conduction, convection, and black body radiation), thermal runaway can occur. The battery will continue to take very large amounts of current from the rectifier and excessive gassing and overheating will result.

WARNING!

In the most severe cases of thermal runaway, equipment can be damaged by sulfuric acid mist that escapes the battery, hydrogen can build up to dangerous levels, and battery cases can rupture because of weakening and melting of the plastic. Ruptured cases can lead to ground faults.

To minimize the risk of thermal runaway:

1. Use temperature compensated chargers
2. Never allow the batteries to exceed 131ºF (55ºC)
3. Make sure cabinets are properly ventilated
4. Provide spacing between batteries to enhance convective cooling
5. Visit sites annually to check for shorted cells, improperly set voltages, filter cleaning on ventilation systems, etc.

2.2 Recharge Following Discharge

Recommended Charge

The recommended recharge method to maximize battery life is to charge with a constant voltage equal to the float charge voltage (2.27Vpc at 68ºF (20ºC)) (see Table 2-1) and a maximum charge current of 0.25 C_8 amperes.

Fast Charge

If it is necessary to reduce the recharge time, charge with a maximum voltage of 2.4Vpc at 68ºF (20ºC) and a maximum current of 0.25 C_8(use the temperature adjustment formula in section 3.1 for voltage adjustment). This recharge should be used no more than once per month to maximize the service life of the battery.

WARNING!

Avoid situations where excess current is available to recharge the battery. This can occur when the DC load is low relative to the charger or maximum rectifier output, and the battery is fully discharged. If too much current enters the battery, the battery can heat up excessively, be permanently damaged, or may cause an explosion.

2.2 Recharge Following Discharge

Using a current limit of 0.1 C_{10}, it takes approximately 9 hours to restore 80% of the discharge, and 11 hours to restore 90%. This can be compared to a current limit of 0.25 C_{10}, whereby 80% is returned in approximately 4 hours, and 90% within 5 hours.

NOTE:

While less charger (rectifier) amps means a longer recharge time, too many charger (rectifier) amps can damage the battery.

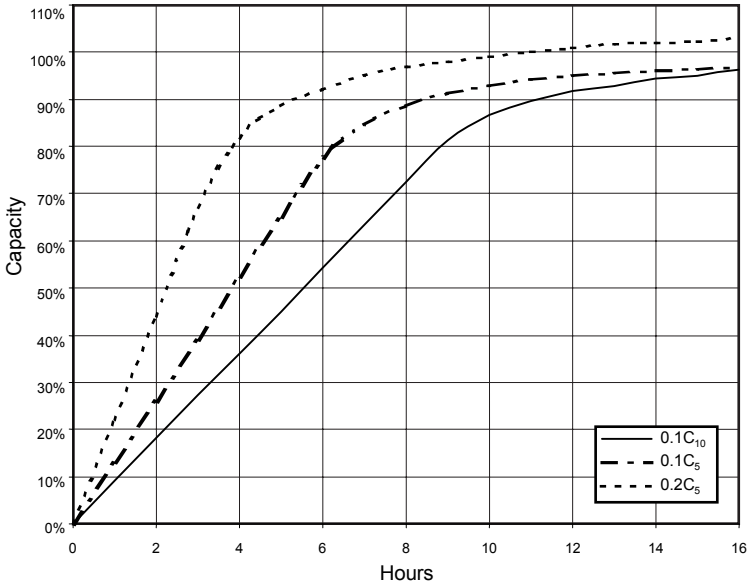


Fig. 2-1, Recharge Time and Capacity Restored as a Function of Current Limit

3.0 Storage

Open circuit

When a battery is stored in an open circuit, two major things occur:

1. Sulfate leaves the electrolyte and reacts with the plates, causing a reduction in the charge state of the battery.

2. Grid corrosion accelerates, especially when the open circuit voltage of the battery is allowed to go below 2.05Vpc.

The state of charge of lead acid batteries slowly decreases in an open circuit due to self-discharge. In SMU-F batteries, the rate of self-discharge is about 2–3% per month at 77ºF (25ºC). During prolonged storage it is necessary to boost-charge the battery at least every 6 months to maintain a fully charged condition of the battery (see Section 2.2). Excessive open circuit storage of any lead acid battery without recharge will result in a permanent loss of capacity. When stored at higher temperatures, the boost interval should be more frequent. Keep the open circuit voltage (measured in a fully rested state of at least 16 hours) at or above 2.05Vpc to minimize the amount of irreversible grid corrosion.

Storage Temperature ºF (ºC)	Boost Interval
77 (25)	6 Months
95 (35)	3 Months
113 (45)	1 Month

Table 3-1, Boost Charge Intervals

4.0 Discharge Specifications

Specifications are subject to change without notice.

Model: SMU-F12-50-FR

End Voltage	Discharge Time														
	1m	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	193	175	88.0	55.0	33.0	20.0	14.0	11.9	10.0	8.50	6.50	5.50	4.85	2.95	2.55
1.65V	185	161	84.0	53.0	32.0	19.5	13.5	11.5	9.70	8.40	6.50	5.40	4.80	2.90	2.50
1.67V	182	155	82.5	52.0	31.5	19.3	13.3	11.3	9.60	8.30	6.45	5.35	4.75	2.88	2.45
1.70V	178	149	81.0	51.0	31.0	19.0	13.0	11.1	9.50	8.20	6.40	5.30	4.70	2.85	2.40
1.75V	156	133	75.0	49.0	30.0	18.5	12.5	10.6	9.20	8.00	6.30	5.20	4.60	2.80	2.35
1.80V	139	120	71.0	48.0	28.0	17.6	12.0	10.2	9.00	7.80	6.00	5.00	4.50	2.72	2.30
1.83V	127	111	68.0	46.0	26.0	17.2	11.7	9.95	8.80	7.60	5.80	4.90	4.30	2.70	2.27
1.85V	120	106	67.0	45.0	25.0	17.0	11.5	9.78	8.80	7.50	5.70	4.80	4.20	2.65	2.24
1.90V	100	91.0	61.0	43.0	23.0	16.5	11.0	9.35	5.90	7.20	5.60	4.70	4.10	2.60	2.20

Model: SMU-F12-75-FR

End Voltage	Discharge Time														
	1m	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	290	262	131	83.0	48.0	30.5	21.0	17.9	15.0	12.8	9.70	8.20	6.90	4.20	3.55
1.65V	278	241	125	79.0	47.0	30.0	20.2	17.2	14.6	12.7	9.60	8.10	6.80	4.15	3.50
1.67V	273	232	124	77.5	47.0	29.5	19.9	16.9	14.4	12.6	9.55	8.05	6.75	4.13	3.48
1.70V	267	223	122	76.0	47.0	29.0	19.5	16.6	14.2	12.4	9.50	8.00	6.70	4.10	3.45
1.75V	234	199	112	73.0	45.0	28.0	18.7	15.9	13.8	12.0	9.30	7.80	6.60	4.00	3.40
1.80V	208	180	106	71.0	41.0	26.0	18.0	15.3	13.5	11.6	9.00	7.50	6.30	3.90	3.30
1.83V	191	167	102	69.0	39.0	25.0	17.5	14.9	13.3	11.4	8.70	7.30	6.20	3.80	3.20
1.85V	180	159	100	68.0	38.0	24.0	17.2	14.6	13.2	11.3	8.60	7.20	6.10	3.70	3.10
1.90V	150	136	92.0	65.0	34.0	23.0	16.5	14.0	12.2	10.8	8.20	6.60	5.80	3.60	3.00

Model: SMU-F12-85-FR

End Voltage	Discharge Time														
	1m	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	371	321	164.0	97.8	58.7	35.6	24.8	21.1	15.9	13.7	11.00	8.94	7.63	4.47	3.74
1.65V	355	301	158.0	96.6	57.5	35.6	24.8	21.1	15.8	13.7	10.90	8.84	7.53	4.47	3.74
1.67V	343	292	155.0	96.1	57.0	35.6	24.8	21.0	15.8	13.7	10.85	8.79	7.48	4.47	3.69
1.70V	331	283	152.0	95.5	56.4	35.6	24.7	21.0	15.7	13.7	10.80	8.74	7.42	4.47	3.64
1.75V	298	255	144.0	93.2	54.9	35.6	24.4	20.7	15.7	13.6	10.70	8.63	7.31	4.37	3.64
1.80V	266	230	136.0	90.9	52.9	35.0	24.3	20.7	15.6	13.4	10.60	8.50	7.21	4.37	3.54
1.83V	245	216	131.0	88.4	50.3	33.5	23.0	19.6	15.1	13.0	10.40	8.42	7.21	4.26	3.54
1.85V	230	202	127.0	86.3	48.3	32.4	21.6	18.4	14.6	12.6	10.10	8.32	7.10	4.16	3.54
1.90V	191	174	117.0	82.8	45.5	31.0	20.3	17.3	13.4	11.6	9.50	8.11	7.00	4.16	3.43

Table 4-1, Discharge Data (A, 70–77ºF (21–25ºC))

4.0 Discharge Specifications, continued

Specifications are subject to change without notice.

Model: SMU-F12-105-FR

End Voltage	Discharge Time														
	1m	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	399	345	177	106	63.0	41.0	28.7	24.4	18.9	16.4	13.1	10.6	8.90	5.40	4.50
1.65V	382	324	170	104	62.0	40.9	28.5	24.2	18.8	16.3	13.0	10.5	8.80	5.35	4.45
1.67V	369	314	167	104	62.0	40.9	28.4	24.1	18.8	16.3	13.0	10.5	8.75	5.33	4.43
1.70V	356	304	163	103	62.0	40.8	28.3	24.1	18.7	16.3	12.9	10.4	8.70	5.30	4.40
1.75V	321	274	154	100	59.0	40.7	28.0	23.8	18.7	16.2	12.8	10.3	8.60	5.20	4.35
1.80V	286	247	146	98.0	57.0	40.0	27.8	23.6	18.5	16.0	12.6	10.0	8.50	5.15	4.30
1.83V	264	233	141	95.0	54.0	38.6	26.3	22.4	18.0	15.5	12.4	9.90	8.40	5.10	4.25
1.85V	247	218	136	93.0	52.0	37.6	24.7	21.0	17.5	15.0	12.0	9.80	8.30	5.00	4.20
1.90V	206	187	127	89.0	49.0	35.5	23.2	19.7	16.0	13.9	11.3	9.70	8.20	4.90	4.10

Model: SMU-F12-125-FR

End Voltage	Discharge Time														
	1m	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	483	437	251	147	84.0	49.7	36.3	30.9	23.0	19.5	15.1	13.2	11.4	7.40	6.20
1.65V	463	403	245	143	83.0	49.1	36.1	30.7	22.6	19.0	15.0	12.8	10.9	7.10	6.00
1.67V	454	388	241	143	83.0	48.8	35.8	30.4	22.3	18.8	14.8	12.8	10.8	6.85	5.80
1.70V	445	373	236	143	83.0	48.5	35.5	30.2	22.0	18.5	14.5	12.7	10.7	6.60	5.60
1.75V	390	332	225	138	83.0	48.4	35.3	30.0	21.5	18.2	14.0	12.6	10.6	6.50	5.50
1.80V	347	280	204	127	80.0	47.1	34.6	29.4	21.0	18.0	13.7	12.5	10.5	6.40	5.40
1.83V	319	275	183	118	78.0	46.8	34.2	29.1	20.7	17.7	13.4	12.5	10.5	6.40	5.40
1.85V	300	271	174	114	76.0	45.8	33.6	28.6	20.5	17.5	13.2	12.4	10.3	6.30	5.30
1.90V	276	219	145	104	71.0	41.8	31.0	26.4	20.0	17.0	13.0	12.2	10.2	6.20	5.21

Table 4-2, Discharge Data (A, 70–77ºF (21–25ºC))

4.0 Discharge Specifications, continued

Specifications are subject to change without notice.

Model: SMU-F12-155-FR

End Voltage	Discharge Time														
	1m	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	592	512	263	158	93.0	60.9	42.7	36.3	28.2	24.3	19.4	15.8	13.3	8.20	6.90
1.65V	568	482	252	154	93.0	60.7	42.4	36.0	28.0	24.2	19.3	15.6	13.1	8.00	6.70
1.67V	549	467	247	154	92.5	60.7	42.2	35.9	27.9	24.2	19.2	15.5	13.0	7.95	6.65
1.70V	529	451	242	153	92.0	60.6	42.0	35.7	27.8	24.2	19.1	15.4	12.9	7.90	6.60
1.75V	477	407	229	149	88.0	60.4	41.6	35.4	27.8	24.0	18.7	15.3	12.8	7.80	6.50
1.80V	428	367	217	145	84.0	59.0	41.3	35.1	27.5	23.7	18.7	15.0	12.7	7.70	6.40
1.83V	392	275	183	118	78.0	46.8	34.2	29.1	20.7	17.7	13.4	12.5	10.5	6.40	5.40
1.85V	367	324	202	138	77.0	55.8	36.7	31.2	26.0	22.2	17.9	14.5	12.3	7.60	6.40
1.90V	306	278	187	132	73.0	52.8	34.4	29.2	23.7	20.7	16.8	13.6	11.9	7.20	6.00

Model: SMU-F12-170-FR

End Voltage	Discharge Time													
	5m	15m	30m	1h	2h	3h	4h	5h	6h	8h	10h	12h	20h	24h
1.60V	562	285	204	120	74.4	52.1	39.5	32.2	28.4	22.1	18.1	15.3	9.46	7.95
1.66V	543	277	201	129	74.2	52.0	39.4	32.1	28.4	21.9	18.1	15.1	9.44	7.95
1.70V	525	269	197	127	74.0	51.0	39.0	31.9	28.0	21.7	17.7	14.8	9.40	7.87
1.75V	503	260	190	125	71.7	50.0	38.1	31.7	27.7	21.5	17.3	14.5	9.32	7.83
1.80V	461	245	181	120	70.7	48.3	37.0	31.3	26.5	20.9	17.0	14.4	9.15	7.64
1.85V	406	218	163	111	69.0	47.5	36.0	29.9	26.4	20.8	16.8	14.3	8.79	7.35
1.90V	355	198	145	94	64.2	41.0	33.1	28.1	24.9	18.9	15.3	14.1	8.49	7.12

Table 4-3, Discharge Data (A, 70–77ºF (21–25ºC))

5.0 Forms

Charging Recording Form

Record before charging and two hours after

Model of Battery		Date	
Battery Bank No.		Room Temperature	
Charging Current		Total Battery Voltage	
Remarks			

Cell #	Voltage	S.G. of Electrolyte	Electrolyte Temperature

NOTE:

Wait two hours before taking final readings to allow the electrolyte to cool.

Fig. 5-1, Charge Recording Form

5.0 Forms, continued

Discharge Recording Form

Model of Battery		Date	
Battery No.		Room Temperature	
Charging Current		Total Battery Voltage	

Remarks	

Cell #	Inital Voltage	Cell Voltage at Time Period End							
		15min	30min	1hr	2hr	3hr	4hr	4:30hr	5 hr

Fig. 5-2, Discharge Recording Form

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